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TITLE

METHOD FOR THREE-DIMENSIONAL IDENTIFICATION OF OBJECTS

BACKGROUND OF THE INVENTION

The present invention is directed to a method for fast three-dimensional identification of objects, particularly for identifying faces. Such methods can be utilized in checking ~~an~~ access authorization for specific rooms or buildings ~~or, respectively~~, for ~~an~~ access authorization for specific automated teller machines ~~automats~~.

There is an increasing need for extremely secure monitoring systems in conjunction with access authorization to specific things such as, for example, automated ~~automatic~~ teller machines. A number ~~plurality~~ of person-specific features are ~~is~~ thereby checked. The recognition of the face is thereby accorded a significant part.

Various security systems are already in field trials. For example, the check or chip card, which is cited herein, stores ~~card is to be cited here~~, a number of features of the face of the owner. ~~being capable of being stored thereon~~. A user only receives access when, for example, a coding number as well as features of the face recognized by the automatic unit coincide with stored data. The coding number is, for example, a ~~the~~ PIN (personal identification number). The facial ~~face~~ features are extracted from a gray-scale image registered by a video camera. These are ~~This is thereby~~ essentially ~~a matter of~~ simple geometrical identifiers in one plane such as, for example, ~~the~~ eye spacing, ~~the~~ spacing between mouth and eye ~~access~~, etc. Despite the relatively indefinite relationship between a two-dimensional gray-scale image and the actual shape of the face, which is essentially clearly three-dimensionally expressed, extremely good results can already be achieved with known evaluation methods such as, for example, with neural networks. The recognition dependability hitherto lay at approximately 98%. A critical disadvantage of the previous methods is that these can be fooled relatively easily such as, for example, with a photograph held in front of the face.

For three-dimensional object recognition, it is known to employ the principle of encoded light application in conjunction with triangulation. The critical feature of this measuring principle lies in the space-time encoding of the work space to be measured, which is the object surface. The work space is illuminated by a chronologically successive projection of, for example, stripe patterns (gray-

encoded stripe patterns). The stripe patterns thereby enable the distinction of different projection directions that are characterized by a characteristic light-dark sequence. For three-dimensional measurement ~~measuring~~ of an object scene, the patterns, which generated with the assistance of a transparent LCD (liquid crystal device) and deformed on the object ~~at the objects~~ of the scene, are observed by a camera from a direction different ~~differing~~ from the illumination direction.

Given known positions ~~position~~ between camera, projector and object scene, the three-dimensional coordinates of the observed scene can be calculated by triangulation in a conventional way.

The previously known employment of transparent LCDs as light-modulating, optionally transparent elements involves a comparatively long acquisition time since the LCDs exhibit very long switching times. This approach is unsuitable for ~~a~~ fast acquisition (for example, 0.1 seconds for a personal identification).

A rapidly switchable light modulation element that, moreover, can be versatilely driven is known from ~~the company publication of Texas Instruments cited below:~~

"Larry J. Hornbeck, Digital Light Processing and MEMs: Timely Convergence For A Bright Future, Texas Instruments Digital ~~Ddigital~~ Imaging Components, Dallas/Texas 75265, 23. - 24 Oct. 1995", Austin, Texas, USA.

A digital micro-mirror arrangement (DMD, Digital Micromirror Device) described therein can accomplish a digital light processing (DLP). This light-modulating element is composed of a number ~~plurality~~ of mirrors micro-mechanically applied on an integrated circuit (chip), these being drivable individually or in groups. The number ~~plurality~~ of mirrors can amount to up to 48,000 per chip. Normally, a DMD chip can be driven with an 8-bit word, as a result whereof 256 gray scale steps derive. Since this light-modulating element is initially used for ~~a~~ television or, ~~respectively~~, video applications, further data is ~~are~~ correspondingly based on video-technical devices. A critical feature, however, is comprised therein that the switching times lie in the range of microseconds. The reproduction of a television image is thus enabled by employing, for example, a three-color illumination of the

chip, whereby the DMD chip is correspondingly electronically driven. The image presented by the ~~plurality~~ number of correspondingly driven mirrors can be projected onto a screen. An optical element of the described type can thus generate a high resolution and a very good contrast.

SUMMARY OF THE INVENTION

The present invention is based on the object of acquiring the topography of three-dimensional objects by encoded illumination and with television picture processing significantly faster without thereby significantly increasing the system costs.

~~This object is achieved by the features of claim 1.~~

~~Advantageous developments can be derived from the subclaims.~~

In addition to ~~the evaluation of the~~ evaluating two-dimensional images, ~~the evaluation~~ the present invention evaluates of three-dimensional face shapes can be utilized according to the invention, this ~~containing~~ contain significantly more extensive and more dependable information. The advantages resulting therefrom lie in ~~a~~ higher recognition dependability ~~that is higher by factors~~, as a result whereof a considerably greater ~~plurality~~ number of persons can be identified. Contours or sections in different planes ~~can then be~~ are utilized as features for recognizing a three-dimensional surface. A basic prerequisite for a fast recognition with extremely high recognition dependability is the complete and correct acquisition of the surface topography. Triangulation in conjunction with an encoded illumination is available as a method. Given the known gray code illumination, a stripe pattern is projected onto the object, the periodicity thereof being varied. For example, the numbers of lines are doubled. Given n different periodicities that are registered in n images, two super n depth planes are obtained given this method. Accordingly, at least six different encoded images are required for 64 depth planes. This method requires a fast switching of the illumination images since the recognition procedure given a real face registration must be ended in a very short time because a person generally does not stand still for very long. The liquid crystal modulators currently available for this purpose require a time span of approximately 0.1 seconds for the information registration for three-dimensional acquisition. New possibilities are opened up in this approach by the substitution of the liquid crystal modulator. This is inventively achieved by a

micro mirror modulator (DMD, Digital Micromirror Device, DMD microchip). This element, which is composed of a ~~plurality~~ number of switchable micro mirrors that can be individually driven, ~~is in the position to apply~~ applies an encoded illumination onto a three-dimensional surface, whereby different illumination patterns can be generated with high resolution and high contrast. Over and above this, this can occur with adequately high switching frequency, so that a ~~plurality~~ number of images can be sequentially acquired in a short time for light encoding methods.

Over and above this, the invention also enables the ~~umproblematical~~ unproblematic utilization of an encoded illumination with different colors, so that three depth planes can be simultaneously ~~already~~ acquired with one television frame. The evaluation of the three color channels of red, green and blue of a color camera is thereby used.

The combination of encoded illumination, the digital micro mirror system, as well as color image processing ideally supplies the fast acquisition and high recognition dependability for the recognition of three-dimensional objects, for example for ~~recognizing face~~ face recognition. A face identification system of this type can be realized of cost-beneficial ~~components of consumer electronics~~ consumer electronics components.

The present invention enables the introduction of directly acquired three-dimensional data of the human face for personal identification. In general, a method for fast, high-resolution and cost-beneficial acquisition of the three-dimensional data of a human face is made available, whereby the combination of an encoded illumination with a digital micro mirror element is utilized. The color image processing can be optionally added and reduces the acquisition time to one-third. Ins a27

~~Exemplary embodiments are described below with reference to schematic figures~~.

Figure 1 ~~shows~~ is a schematic arrangement of component parts for three-dimensional face recognition with digital light and color-image processing;

Figure 2 ~~shows~~ are examples of the three-dimensional face recognition on the basis of geometrical data.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENT

a ~~The~~ right-hand image half of an object surface 7 can be seen in Figure 1. Theoretically, a ~~the~~ digital micro mirror arrangement 3, which is illuminated with a ~~the~~ light source 1, can generate an arbitrary image at the location of the object ~~objects~~ 7. For the purpose of the present invention, however, ~~an~~ object 7 ~~is present here that~~ is correspondingly radiated with encoded illumination, so that an encoding 10 appears on the object 7. The beam path emanating from the light source 1 is respectively suitably formed preceding and following a color filter 2 by ~~a~~ respective optics 4. The color filter 2 is composed of a rotating disk that comprises a chromatic, light-permeable strip at the circumference that is uniformly divided into ~~a~~ red, green and blue areas ~~area~~. Color ~~A color~~ image processing is thus enabled. a ~~The~~ digital light processor 9 comprises ~~processing 9 is composed of~~ a digital micro mirror arrangement ~~arrangements [sic]~~ 3. This arrangement 3 is what is referred to as a DMD chip (digital micro mirror arrangement, digital miro mirror device). a ~~The~~ camera 6 is controlled in addition to the light processor ~~processing~~ 9 with a ~~the~~ control and evaluation unit 11. The projection of ~~the~~ light ensues behind the digital micro mirror arrangement 3 by a ~~the~~ projection lens 5 onto the object surface 7. The corresponding light encoding has thereby been applied by the digital micro mirror arrangement 3. The camera 6 must be a color picture camera for a color picture evaluation.

An encoded illumination 10 is first projected such onto the object 7 via the digital micro device arrangement 3 ~~mirror device~~ in the color image evaluation such that three striped patterns with respectively different color (for example, red, green, blue) and periodicity are simultaneously present in a video frame. Due to the separate and parallel registration of the three different color patterns, the information for calculating three depth planes can thus be acquired in a video frame. In order, for example, to assure the evaluation of a face surface within 0.1 seconds with extremely high recognition dependability, this face is illuminated with an encoded, in this case stripe-like encoding 10, whereby the stripes exhibit different periodicities in successive images. The face is thereby acquired, for example, by 200 x 200 x 150 picture elements having a spatial resolution of 2 x 2 x 2 mm. The underlying principle of the height measurement at the object 7 is, for example, triangulation. The previous problem of a fast switching of the illumination images for the stripe-